

Production of Mottled Enamel Halted by a Change in Common Water Supply*

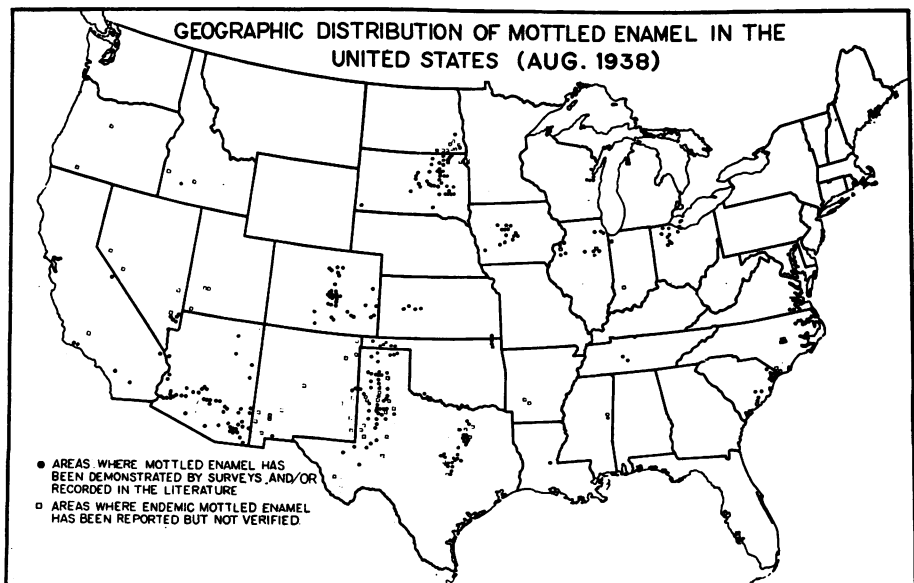
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IN the United States at present there are about 375 known areas, divided among 26 states where mottled enamel of varying degrees of severity is found. This large number of areas made avail-

able for study various communities whose common water supplies contained fluorides in different concentrations. This, in turn, permitted detailed quantitative study of concomitant variations.

FIGURE I



*Read before the Epidemiology Section of the American Public Health Association at the Sixty-seventh Annual Meeting in Kansas City, Mo., October 25, 1938.

A recent report¹ summarized studies on the quantitative relation between the fluoride concentration of the common

TABLE I

Illustration of Quantitative Relation Between the Fluoride (F) Concentration of the Common Water Supply and Severity of Clinical Affection

City and State	Number of Children Examined	Mean Annual Fluoride (F) Content in p.p.m.	Percentage Incidence of Affection	Percentage Distribution of Clinical Severity						Age Group or School Grade Examined
				Pathognomonic Signs						
				Absent		Present				
				Normal	Quest.	Very Mild	Mild	Moderate	Severe	
Pueblo, Colo.	83	0.6	2.4	88.0	9.6	2.4	...	...	...	9 Year
Jct. City, Kans.	115	0.7	1.7	95.7	2.6	1.7	...	...	...	9-10-11 yrs.
Big Spring, Tex.	68	0.7	3.0	85.3	11.7	3.0	...	...	...	5th, 6th Gr.
Mullins, S. C.	47	0.9	10.6	68.1	21.3	8.5	2.1	...	...	9-10-11 yrs.
East Moline, Ill.	110	1.5*	24.5	55.5	20.0	18.2	5.4	0.9	...	"
Webster City, Iowa	72	1.6	26.4	65.3	8.3	22.2	4.2	...	...	"
Monmouth, Ill.	38	1.7	42.1	36.8	21.0	36.8	5.3	...	...	9 Year
Galesburg, Ill.	57	1.8	35.1	45.6	19.3	26.3	5.3	3.5	...	"
Clovis, N. M.	138	2.2	71.0	13.0	16.0	23.9	35.4	11.0	0.7	9-10-11 yrs.
Colo. Spr., Colo	148	2.5	67.6	18.2	14.2	28.4	21.6	14.2	3.4	9 Year
Plainview, Tex.	77	2.9	87.0	3.9	9.1	33.7	24.7	24.7	3.9	9-10-11 yrs.
Amarillo, Tex.	229	3.9†	89.5	3.5	7.0	16.6	24.9	34.5	13.5	"
Conway, S. C.	59	4.0	88.2	5.1	6.7	20.4	32.2	23.7	11.9	"
Lubbock, Tex.	168	4.4	97.5	1.2	1.2	10.7	24.4	44.0	18.5	"
Post, Tex.	38	5.7	100.0	...	...	...	10.5	50.0	39.5	4, 5, 6 Gr.
Ankeny, Iowa	21	8.0‡	100.0	...	...	...	9.5	47.6	42.8	2-12 Gr.

* Subject to possible correction to 1.3 p.p.m.

† Subject to possible correction to 4.2 p.p.m. during susceptible period of the age group examined.

‡ Single determination, all others, arithmetical mean of 12 consecutive monthly samples.

(Computed largely from data recorded in *Public Health Reports*, 52:1249-1264 (Sept. 10), 1937, and *American Journal of Public Health*, June, 1936.)

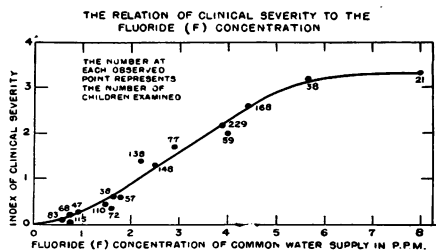
water supply and the clinical effect. Quantitative increase in the fluoride concentration of the domestic water was concurrent with an increase in the amount and degree of clinical severity. The direct verification of concomitant variation is shown in Table I. In order to present these tabular data graphically, a numerical index of clinical severity was computed by giving a definite weight to each of the several degrees of clinical affection. The following weights were given to each diagnosis: Normal, 0; Questionable, 0.5; Very Mild, 1; Mild, 2; Moderate, 3; and Severe, 4. The weighted index of clinical severity was then plotted against the fluoride concentration of the communal water supply. Figure II shows a rather precise quantitative correlation.

CONSEQUENCE OF CHANGE IN THE COMMON WATER SUPPLY

A more cogent type of epidemiological evidence is now added to that shown by concomitant variations. Three com-

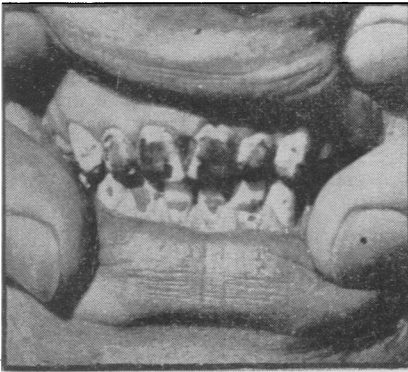
munities where the endemicity of mottled enamel had been confirmed by survey, changed their communal water supply from one containing a fluoride concentration now known to be sufficient to produce endemic mottled enamel to one practically free of fluorides. Each community presented the indispensable conditions of a susceptible population * using the "new" water supply and a sufficient lapse in time (8-10 years) for a study of the consequent

FIGURE II

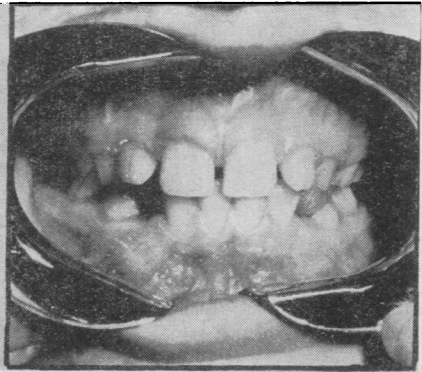


* Children in whom the crowns of their permanent teeth were calcifying.

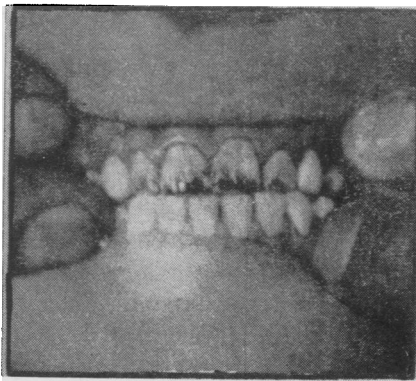
CHILDREN WHO CALCIFIED THEIR PERMANENT TEETH WHILE USING:



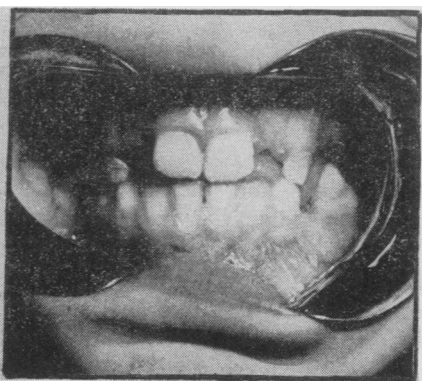
"Old" Bauxite Water
Mottled Enamel: Severe



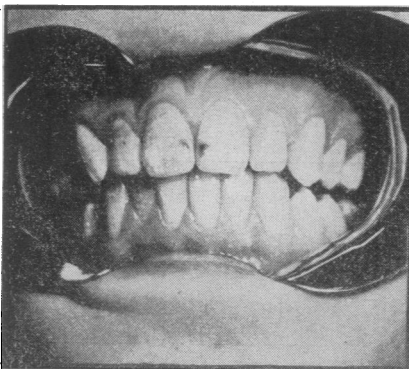
"New" Bauxite Water
Normal



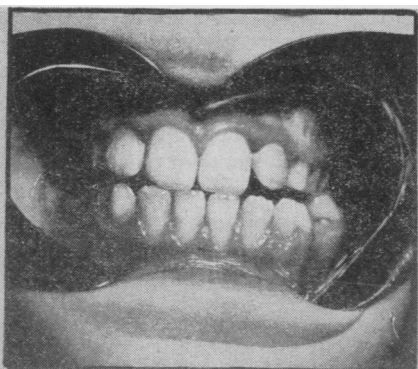
"Old" Oakley Water
Mottled Enamel: Moderate



"New" Bauxite Water
Normal



"Old" Oakley Water
Mottled Enamel: Mild



"New" Oakley Water
Normal

differences. The two sets of circumstances were similar in all respects save for the one difference, the change in the water supply. The surveys made prior to the change in the water supply and the resurvey made after the requisite lapse of time were made by either one or the other of the writers. The communities studied were: Oakley, Ida., Bauxite, Ark., and Andover, S. D.

Oakley, Ida.—The first instance of a community changing its public water supply solely for the purpose of preventing mottled enamel is that of Oakley, Ida. A survey of this community was made by one of us² in February, 1925. Seventy-eight children whose histories indicated continuous residence and uninterrupted use of the common water supply were examined. The incidence of affection was 100 per cent. The common water supply of Oakley at the time of the survey was obtained from a warm spring. Following the survey, the community on July 1, 1925, changed its water supply, the new supply being obtained from a nearby cold water spring. The selection of this water was based on the observation that the 4 children of a family using this spring were free of mottled enamel.

Approximately 7½ years (February, 1933) after the change in the common water supply, Oakley was resurveyed.³ Twenty-four children born since the change in the water supply were examined. *All showed normal calcification* in those permanent teeth which at that time had erupted. According to analyses³ made by Churchill, the "old" Oakley water contained 6.0 p. p. m. of fluorine; the "new" supply, less than 0.5 p. p. m.

Bauxite, Ark.—In February, 1928, a mottled enamel survey of Bauxite was made by Kempf and McKay.⁴ Sixty of the 62 children of continuous residence examined showed mottled enamel, generally of a severe type. Of the two classified as normal,

Kempf and McKay recorded in a footnote that although the homes of these children were piped for the city water, it appears that it was only used occasionally for domestic purposes. The water used by the 60 affected children examined during the 1928 survey was obtained from deep wells and, according to Churchill,⁵ contained 13.7 p. p. m. of fluoride (F).

In May, 1928, the Bauxite water supply was changed, the "new" supply being obtained from the nearby Saline River. A resurvey⁶ by the writers in March, 1938, showed that of the 45 children born since the change in the water supply, only 2 showed even the mildest form of mottled enamel.* The "new" filtered river water supply is practically free of fluorides, containing less than that determinable routinely (0.2 p.p.m.).

Andover, S. D.—In 1916, one of us (F. S. McK.) made a qualitative survey of the school children of Andover and found mottled enamel endemic, associated with the use of the water from the city artesian well supply.⁷ In 1928 this deep well water supply† failed and the community was forced to change from the 800' artesian to a dug shallow well 22' deep. An examination of the school children by one of the writers (H.T.D.) in April, 1938, showed that

* A possible explanation of the two "very mild" cases is contained in the detailed report of the Bauxite resurvey (*Pub. Health Rep.*, 53:1736-1748 (Sept. 30), 1938). The fluoride (F) content of the "old" Bauxite water was so unusually high, 13.7 p.p.m., that the question of antepartum maternal fluorosis and subsequent transfer of small amounts of fluorides in the mother's milk cannot be excluded. The 7 year old child with the "very mild" diagnosis was nursed 15 months. Consideration might also be given to possible fluoride deposits from the "old" supply in the water pipes and cooking utensils.

† The fluoride content of the "old" Andover (S.D.) deep well water is not known, but presumptive evidence based on clinical mottled enamel among those who calcified their permanent teeth while using this water indicates that it contained fluorides, probably in the neighborhood of 2.5-3.0 p.p.m. of fluorine. Wells of comparable depth in the immediate rural district are likewise producing mottled enamel.

cooking. In the case of the resurvey at Bauxite, the facts with respect to residence and water consumption were verified in each instance by an interview with the child's parent.

In specific water-borne diseases, the time intervening between the elimination of the antecedent cause and the nonappearance of the pathological entity is relatively short. The opposite characteristic of endemic dental fluorosis (mottled enamel) makes it unique among the water-borne diseases. An interval in time between 8 to 10 years is required to carry out a human experiment that furnishes clinical proof that the development of the disease has stopped.

With the report on the results obtained at Oakley, Ida., Bauxite, Ark., and Andover, S. D., showing that the production of mottled enamel has actually been stopped by the mere change in the water supply from one containing concentration of fluorides toxic to calcifying dental enamel to one practically free of fluoride (or less than 1.0 p.p.m.), the most conclusive and direct proof that fluoride in the drinking water is the primary cause of human mottled enamel has been presented. The separate steps in the complete chain of evidence may now be summarized as follows:

1. The evidence pointing to mottled enamel being a water borne disease.^{8, 7}

2. The finding of fluorides in domestic waters associated with the production of mottled enamel.^{9, 5, 10}

3. The experimental production of dental lesions in white rats and dogs by waters from endemic areas and waters to which fluoride has been added.^{9, 11, 12}

4. Quantitative epidemiological studies on human mottled enamel correlating the fluoride concentration of the domestic water with the degrees of clinical severity.^{13, 1}

5. And finally, after the lapse of the necessary interval of 8 to 10 years, the clinical evidence that the production of human mottled enamel had been halted by merely changing the common water supply from one containing fluorides in concentrations toxic

to calcifying dental enamel to one practically free of fluorides.^{3, 6}

SUMMARY

1. The production of the endemic hypoplasia of the permanent teeth known as mottled enamel has been halted at Oakley, Ida.; Bauxite, Ark.; and Andover, S. D., by simply changing the common water supply from one containing amounts of fluorides toxic to calcifying dental enamel to one whose fluoride content does not exceed the permissible maximum, 1 p.p.m.

2. Oakley, Ida., and Bauxite, Ark., are the first known instances of communities abandoning an otherwise satisfactory common water supply solely for the definite purpose of preventing mottled enamel; and in itself likewise represents the first instance where a common water supply was changed solely for the purpose of preventing a dental disease.

3. The unusually long interval in time (8-10 years) before the clinical effects resultant from a change in the water supply may be observed clinically, is unique in epidemiological investigations of water-borne diseases.

4. With the report on the results obtained in three endemic areas, showing that the production of mottled enamel has actually been stopped by the mere change in the water supply from one containing concentrations of fluoride toxic to calcifying dental enamel to one practically free of fluoride, the most conclusive and direct proof that fluoride in the domestic water is the primary cause of human mottled enamel, has been presented.

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Public Health Administration

IT is indeed the practitioners of medicine, and chiefly the general practitioners, who by their observations at the bedside have pointed out the way to preserve health and have proclaimed the need for public health administration in season and out of season with a most laudable persistence.

Nay, more, the comprehensive character of public health legislation and administration, as we see it today, came into being through public remonstrances by the medical profession against the disorderly state of the early sanitary laws.—Health and The State, Walter Elliot, *Brit.M.J.* Feb. 25, 1939.